

*Expl Agric.* (2007), volume 43, pp. 381–400 © 2007 Cambridge University Press  
doi:10.1017/S0014479707004954 Printed in the United Kingdom

## INDIGENOUS MULTIPLICATION AND PRODUCTION PRACTICES FOR THE TUBER CROP *PLECTRANTHUS EDULIS* IN CHENCHA AND WOLAITA, SOUTHERN ETHIOPIA

By MULUGETA TAYE, WILLEMEN J. M. LOMMIEN<sup>‡†</sup> and PAUL C. STRUIK<sup>†</sup>

*Awassa College of Agriculture, Debub University, P.O. Box 5, Awassa, Ethiopia and <sup>†</sup>Crop and Weed Ecology Chair, Plant Sciences Group, Wageningen University, Haarweg 333, 6709 RZ Wageningen, The Netherlands*

(Accepted 12 January 2007)

### SUMMARY

*Plectranthus edulis* (syn. *Coleus edulis*) is a tuber-bearing labiate species cultivated in parts of southern Ethiopia. To learn about traditional cultural practices and their rationale, a survey was conducted among farmers from Chenchha and Wolaita experienced in growing this crop. A pre-tested questionnaire was used to interview 48 family heads categorized into three wealth groups per site. Information was checked through group discussions and field observations. In Wolaita, poorer farmers cropped a larger portion of their land to *P. edulis* than richer farmers. Land was usually prepared for planting between January and April. In Wolaita, the crop was mostly grown in a furrow. In Chenchha growing in patches and on flat land also occurred. Farmers mostly used a digging hoe for land preparation. Tuber pieces were planted about 5 cm deep. According to farmers, using tuber pieces resulted in more stems, more progeny tubers and higher yields than using whole tubers. Tubers were broken into pieces 0–1 day before planting. Tuber pieces were planted with sprouts or after desprouting. Crops were usually fertilized with manure, but in Wolaita sometimes also with compost. Applying fertilizer was thought to give more and bigger tubers. Earthing up took place 1–3 times (usually twice), to increase yield. Tipping was also done 1–3 times (usually once), to increase the number of stems. Based on the survey, an overview of the practices and their rationale is compiled for use in further research into this orphan crop.

### INTRODUCTION

Owing to the diverse climatic and cultural conditions, numerous groups of crops such as cereals, legumes, leafy vegetables, fruits, and root and tuber crops are grown in southern Ethiopia. Root and tuber crops include enset, Irish potato, sweet potato, yam, cassava, taro and *Plectranthus edulis* (syn. *Coleus edulis*). Depending on the place where *P. edulis* is grown it is known under different names, e.g. *Wolaita dono*, *Gamo dinich*, *Dinicha Oromo*, *Agaw dinich*, *Garage dinich*.

*P. edulis* is a diploid dicotyledonous plant, belonging to the Labiatae (Lamiaceae) family, with a height up to 150 cm. The family consists of over 350 tuber-bearing and non-tuber bearing species distributed predominantly in Africa, Asia and Australia (Codd, 1985). Some of the non-tuber bearing species are grown as ornamental or medicinal plants for their leaves and flowers while the tuber-bearing species are

<sup>‡</sup>Corresponding author. Email: Willemien.Lommien@WUR.nl

cultivated mainly for their tubers. Besides *P. edulis*, tuber-bearing species include *P. parvijlorus* (syn. *Coleus tuberosus*), *C. rotundifolius* and *P. esculentus* (Kay, 1973; Tindall, 1983).

*P. edulis* is said to have originated in Ethiopia, and has been grown in different mid and high altitude areas (Greenway, 1944; Ryding, 2000). Siegenthaler (1963) reported it to be a major highland tuber crop in the southwestern parts of Ethiopia, and Westphal (1975) stated that it was an indigenous crop in the northern, southern and southwestern parts of Ethiopia. Asfaw and Zerihun (1997) reported it to be a major carbohydrate source in Ethiopia. Farmers and the Ministry of Agriculture claim that the total tuber production has declined considerably over the last few decades for unknown reasons. Recently, farmers and governmental and non-governmental organisations have shown a renewed interest in *P. edulis*, for the crop is a traditional food, a major source of energy and not seriously attacked by diseases and insect pests.

However, information on the growth and development of *P. edulis* and on the optimal cultural practices is scarce. Even basic information on the crop is not available. Knowledge of how and why farmers carry out the different cultural practices and information on the production constraints are essential. As described by DeWalt (1994), knowledge of such indigenous practices is important for it may provide useful clues concerning the potential future direction of scientific research on such orphan crops.

The objectives of this survey study were to establish and analyse the traditional cultural production practices in some parts of southern Ethiopia, how they are carried out and how farmers rationalize them. The study also provided information on production constraints, and allows farmers' production methods to be assessed. It also provides information on important differences in cultural techniques among farmers and on ways by which the farmers assume cultural techniques will affect tuber yield and tuber-size distribution. The information can be used to develop a research agenda.

## MATERIALS AND METHODS

### *Study area*

A formal survey was conducted in two *P. edulis* growing areas in southern Ethiopia, namely Chenchu and Wolaita (Figure 1). These areas are among the many places where the crop has been grown widely as a traditional food for many years. Both areas are located in the highlands. Chenchu is 2000–3000 m asl with an average temperature of 18 °C, and Wolaita is 1800–2000 m asl with an average temperature of 23 °C. Both areas receive 1500–2000 mm annual rainfall in a bimodal pattern, i.e. short rains in March–May and long rains in July–September. Chenchu has a total area of 365 km<sup>2</sup> and a population density of about 301 km<sup>-2</sup>. The people in Chenchu are mainly engaged in agriculture and crafting (CSA, 2000). Wolaita has a total area of 429 km<sup>2</sup> and a population density of about 629 km<sup>-2</sup>. The people in Wolaita are mainly engaged in agriculture (CSA, 2000). There are different ethnic groups in both Chenchu and Wolaita. The dominant ethnic groups in both areas belong to the Omotic linguistic family.

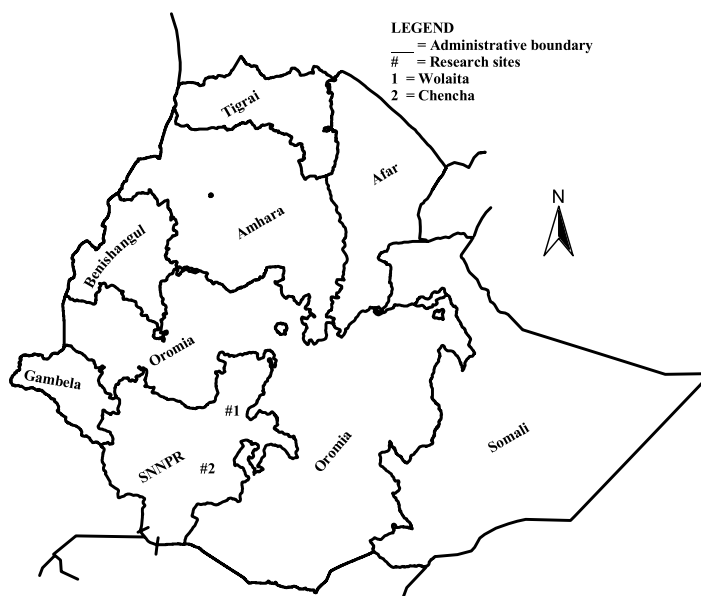


Figure 1. Map of Ethiopia showing the areas where the survey was carried out. SNNPR: Southern Nations, Nationalities and People's Region.

#### *Questionnaire and interviewing*

Apri-validated questionnaire was used to interview farmers growing *P. edulis*. From a list provided by the Bureau of the Ministry of Agriculture, 48 households were randomly selected from four peasant associations from both Chencha and Wolaita. One family head from each household was questioned on belongings, production practices, perception, problems and constraints encountered, and future plans for the production of *P. edulis*. Both closed and open-ended questions were included in the survey. The latter were only used when more information was desired. The interviewing started on June 28, 2002, in Wolaita and two weeks later in Chencha, and ended after about three months. Specially trained enumerators conducted the interviews. In addition, the researchers observed the cultural practices very closely, from land preparation up to time of harvest and storage, particularly in the Wolaita area.

#### *Group discussions*

After analysis of the interview data, discussions with groups of farmers in both areas took place between November 20 and 25, 2002. The groups included both farmers who, at the time, were growing and who had stopped growing *P. edulis*. During the discussions, several questions were raised with particular emphasis on production practices and constraints. The discussions helped to clarify some points that remained vague during the interviews.

#### *Wealth categories*

The respondents were grouped into three wealth categories, namely poor, medium and rich. The wealth categories were based on Aresawem (1993), FARM Africa (1999)

Table 1. Criteria for categorizing *P. edulis* growers in Chencha and Wolaita into three wealth categories.

	Chencha			Wolaita		
	Poor	Medium	Rich	Poor	Medium	Rich
Land area (ha)	<0.25	0.25–1.00	>1.00	<0.25	0.25–1.00	>1.00
Animals						
Oxen	0	0	1–2	0	1–2	2–3
Dairy	0	1	2–3	0	2–3	5–7
Sheep <sup>†</sup>	0	2–3	5–7			
Mule <sup>†</sup>				0	0	1–2
Donkey <sup>†</sup>				0	1	4

<sup>†</sup>Mule and donkey were not considered in Chencha while sheep were not considered in Wolaita.

Table 2. Percentage of respondents in different wealth categories classified according to the percentage land cropped with *P. edulis* in Chencha ( $n = 48$ ) and Wolaita ( $n = 48$ ).

Percentage land cropped to <i>P. edulis</i>	Chencha				Wolaita			
	Poor	Medium	Rich	$\chi^2$ <sup>†</sup>	Poor	Medium	Rich	$\chi^2$ <sup>†</sup>
≤5	33	63	50	3.9 ( $p = 0.422$ )	0	56	80	10.4 ( $p = 0.033$ )
6–15	50	31	50		83	35	10	
≥16	17	6	0		17	9	10	
$n$ <sup>‡</sup>	12	32	4		6	32	10	

<sup>†</sup> $\chi^2$ -analysis was carried out on numbers in different categories per site.

<sup>‡</sup>Number of respondents in each wealth category.

and Admasu Tsegaye and Struik (2002). In this categorization, land area cropped, and animals owned (including oxen, dairy cows, sheep, mules, and donkeys) were the criteria (Table 1).

### Data analysis

Descriptive statistics including percentages and chi-square were carried out using the statistical program SPSS 10.0. A chi-square test on numbers of farmers was used to establish differences between locations or wealth categories in cultural practices and opinions of farmers. Data were recalculated to percentages for presentation.

## RESULTS

### Household characteristics

Over 90 % of the respondents in Chencha and Wolaita had lived in the area for more than 20 years, and 88 % of the respondents in Chencha and 79 % in Wolaita had grown the crop for more than 10 years. Table 2 indicates the land proportion allotted to grow *P. edulis* by different wealth groups. Over 50 % of the farmers allotted ≤ 5 % of their land to *P. edulis*, and around 10 % more than 15 %. The chi-square test showed no significant differences among the wealth groups in the land proportion

allotted to *P. edulis* in Chenchu. In Wolaita, poorer farmers allotted a relatively larger proportion of land to the crop than richer farmers.

#### *Crop cultivation*

In addition to *P. edulis*, respondents in Chenchu and Wolaita cultivated cereals (wheat, barley, maize and/or teff), leguminous crops (bean and/or pea), and root and tuber crops (enset, Irish potato, sweet potato, cassava and/or taro). Of the root and tuber crops, 85 % and 15 % of the respondents in Chenchu indicated that they mostly consumed enset and Irish potato, respectively, and in Wolaita 77 % and 19 % indicated that they mostly consumed sweet potato and Irish potato, respectively. About 75 % of the respondents in Chenchu and 25 % in Wolaita indicated that they consumed less *P. edulis* than the above-mentioned cereals, legumes, and tuber and root crops, mainly because of the low yields.

In both areas all respondents indicated that they grew *P. edulis* alone as a monocrop for it did not perform very well both in terms of growth and yield when planted as an intercrop.

#### *Land races of P. edulis*

Most respondents knew three to four land races. In total, six land races were known in Chenchu: *Lofuwa*, *Unnuka*, *Chankua*, *Merchia*, *Dalakuwa* and *Kaytaria*; five were known in Wolaita: *Lofuwa*, *Unnuka*, *Chankua*, *Merchia* *Nech* and *Kaytaria*. In Wolaita there was a tendency for poor farmers to know fewer land races than farmers who had more resources.

Farmers used various characteristics to identify the land races. Almost all farmers used tuber characteristics, and 40–60 % also used leaf characteristics, time of maturity or storage duration to identify land races. This was similar for Chenchu and Wolaita.

#### *Land preparation*

The land was usually prepared for planting between January and the end of April, with preparation starting earlier in Chenchu than in Wolaita (Table 3). During the discussions, some farmers – particularly those with more land – mentioned that they prepared their land twice, i.e. they carried out the first preparation in October or November and the second one in February. In October and November they used the residual soil moisture from the main rainy season for turning up the soil, and consequently to kill weeds, pathogens and insect pests.

The land was prepared in different forms including furrow, flat (as for cereals), patch and raised bed (Table 3). The patch mode was a kind of spot digging, which was done mostly on virgin land or on land that had not been cultivated for several years, and the digging was made in a space with a depth of 5–10 cm and diameter of about 50–70 cm. In Chenchu, furrows and patches were most often used whereas 13 % used flat planting. In Wolaita, the vast majority of the respondents used the furrow method, and 6 % used raised beds (Table 3).

Table 3. Percentages of respondents using the indicated months of starting land preparation, mode of land preparation and tool for digging/ploughing before planting *P. edulis* in Chench (n = 48) and Wolaita (n = 48).

	Chench	Wolaita	$\chi^2$
Months for preparing the land			
January	31	2	27.0 ( $p < 0.001$ )
February	13	56	
March	23	21	
April	33	21	
Mode of preparing the soil			
Furrow	46	94	36.9 ( $p < 0.001$ )
Flat	13	0	
Patch	42	0	
Raised bed	0	6	
Kind of tool †			
Ox	17	33	6.7 ( $p = 0.035$ )
Digging hoe (toyle)	83	60	
Spade	19	35	

†Note that the sum of all kinds of tools is larger than 100 % in both areas, because some farmers used several tools.

Table 4. Percentage of farmers using the indicated types of planting material with different frequencies in Chench (n = 48) and Wolaita (n = 48).

Type of planting material	Chench			Wolaita			$\chi^2$
	Often	Occasionally	Never	Often	Occasionally	Never	
Whole tubers	0	0	100	2	17	81	10.0 ( $p = 0.007$ )
Tuber pieces	100	0	0	100	0	0	0
Stem cuttings	0	0	100	0	6	94	3.1 ( $p = 0.213$ )
Sprout cuttings	0	0	100	0	4	96	2.0 ( $p = 0.360$ )
True seed	0	0	100	0	0	100	0

Digging hoes (*toyle*), spades and ox-pulled ploughs were used to dig the land (Table 3). The hoe is a kind of forked digging tool with two long 'fingers'. It was mostly used on small plots, while an ox-pulled plough was mostly used on large plots and plain terrain. The digging hoe was the most frequently used tool in both Chench and Wolaita, and was even more frequently used in Chench than in Wolaita (Table 3).

#### Planting material

*P. edulis* was grown from tuber pieces, whole tubers, stem cuttings and sprout cuttings (Table 4). Stem cuttings are the top part of the branches with a length that varied up to 50 cm, while sprout cuttings are the young outgrowths originating from the tuber, about 10–15 cm in length. Tuber pieces were most frequently used, while the other types of planting material generally were used only occasionally by a few respondents in Wolaita (Table 4). Farmers did not use true seed.

On average for the two sites, about 45 % of the respondents used tuber pieces primarily to increase the number of stems and about 30 % of the respondents indicated

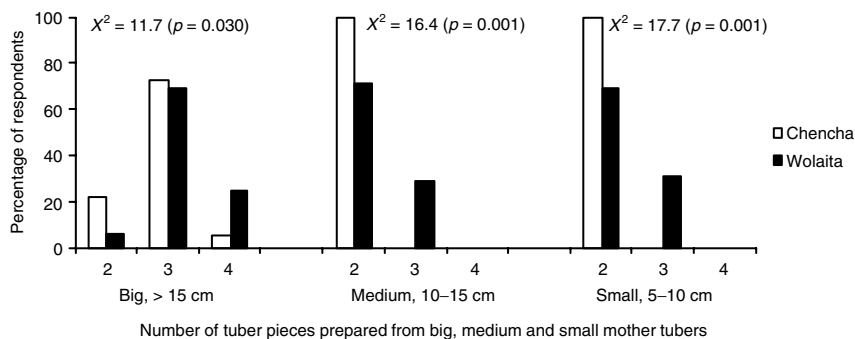


Figure 2. Respondents (%) preparing 2–4 tuber pieces from big, medium and small sized tubers in Chencha ( $n = 48$ ) and Wolaita ( $n = 48$ ).

that using tuber pieces also increased the number of progeny tubers. About 12 % of the respondents indicated that they used tuber pieces because they thought it would give them higher yields. In Chencha a few respondents used tuber pieces merely because it was considered a traditional practice.

*Number of tuber pieces:* From one whole tuber, 2–4 pieces were prepared. The vast majority of respondents broke the medium (10–15 cm) and small (5–10 cm) tubers into two pieces and the big tubers (>15 cm) into three pieces (Figure 2). In Chencha, the number of tuber pieces prepared from whole tubers of different sizes was lower than in Wolaita (Figure 2).

*Time for breaking the whole tuber and treatment after breaking:* In Chencha, most respondents broke the seed tubers one day before planting or on the day of planting, while in Wolaita the vast majority of respondents broke the tubers on the day of planting (Table 5).

Respondents in Wolaita planted the tuber pieces without subjecting them to any treatment (Table 5). In Chencha, some respondents kept the tubers in a dry place in the house, while one respondent mixed the tuber with ash.

Table 5. Percentage of farmers breaking seed tubers into pieces for planting at the indicated time and adopting the indicated treatment of the tuber pieces between breaking and planting in Chencha ( $n = 48$ ) and Wolaita ( $n = 48$ ).

	Chencha	Wolaita	$\chi^2$
Time of breaking seed tubers into pieces for planting			
Day of planting	48	73	9.9 ( $p = 0.019$ )
One day before planting	52	23	
Two days before planting	0	2	
Three or four days before planting	0	2	
Treatment of seed tuber pieces between breaking and planting			
Spreading tubers in dry place in the house	42	0	26.9 ( $p < 0.001$ )
Mixing with ash	2	0	
No treatment	56	100	

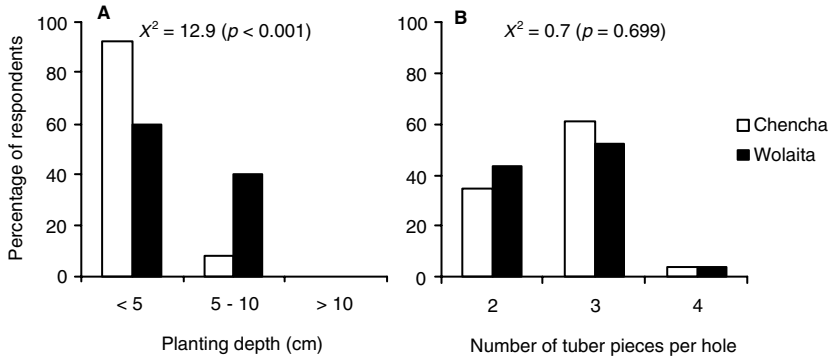


Figure 3. Respondents (%) in Chencha and Wolaita indicating planting of seed tubers or seed tuber pieces at a depth of <5 cm or 5–10 cm (a) and planting 2–4 tuber pieces per hole (b).

### *Planting the tuber pieces*

The tuber pieces could be planted with sprouts, which were produced during storage, or after de-sprouting. In Chencha 67 % of the respondents planted the tuber pieces after de-sprouting; in Wolaita 46 % of the respondents did this. The remaining farmers planted their seed tubers with sprouts. Those respondents who used de-sprouted tubers did so to get more stems, whereas respondents who used sprouted tuber pieces, mainly did so to improve growth.

Planting tuber pieces took place mostly in April, following the short rains that occurred in this month. During the group discussions some farmers indicated that they planted their tubers in March, and relied on the coming of adequate rain.

Tuber pieces were usually planted at an approximate spacing of 60–100 cm between rows (furrows) and 40–75 cm within a furrow row. A wide spacing was preferred because *P. edulis* has a branching growth habit, and because a wide spacing allows practices including earthing up and tipping to occur (see below).

Almost all respondents in Chencha covered the seed tuber pieces with less than 5 cm soil (Figure 3a), whereas in Wolaita 40 % of the respondents covered the tuber pieces with 5–10 cm soil in order to protect the progeny tubers from strong and direct sunlight (Figure 3a).

Most respondents planted three or two tuber pieces at one planting position (Figure 3b). The tubers pieces were planted at some distance from each other within one hole to reduce competition during early growth.

### *Fertilization*

When fertilizing, respondents in Chencha relied entirely on animal manure while in Wolaita 37 % used compost alone or in addition to manure (Table 6).

Most respondents in Chencha indicated that they applied manure at one time or regularly (four times or more), while in Wolaita they generally applied it three times (Table 6). Farmers applied manure at any time until earthing up and placed it around the root system. If the manure was fresh dung, farmers did not place it close to the



Table 6. Percentage of respondents indicating the different fertilization practices and effects of fertilization in Chencha ( $n = 48$ ) and Wolaita ( $n = 48$ ).

	Chencha	Wolaita	$\chi^2$
Type of fertilizer			
Manure only	94	63	24.0 ( $p < 0.001$ )
Compost only	0	6	
Manure and Compost	0	31	
None	6	0	
Number of applications			
0	0	0	77.4 ( $p < 0.001$ )
1	40	0	
2	13	10	
3	4	90	
$\geq 4$	44	0	
Effects on tuber number			
More tubers	94	75	6.8 ( $p = 0.034$ )
No effect	6	21	
Less tubers	0	4	
Effects on tuber size			
Larger tubers	94	63	13.9 ( $p = 0.001$ )
No effect	6	33	
Smaller tubers	0	4	

root system. Because of the fear of ‘burning’ the farmers usually kept the fresh dung on top of the soil for some time and then incorporated it with some soil, thus putting it closer to the root system. The rate of manure application varied approximately between 20 and 30 t ha<sup>-1</sup>. During the group discussions farmers indicated that they kept on applying manure particularly as it became warmer as they thought that this could help to cool down the soil.

Most respondents indicated that fertilization resulted in more and larger tubers, with even more respondents indicating the positive effects in Chencha than in Wolaita (Table 6).

### *Cultivation*

Cultivation involves shallow digging around the root system. More than 90 % of the respondents in Chencha cultivated three times and in Wolaita about 50 % of the respondents cultivated three times and the remaining two and four times (Figure 4a). During the group discussions with the farmers, they indicated that they carried out the first cultivation following the emergence of the shoot. The other cultivations depended on the occurrence of weeds around the stem. Cultivation was carried out for various reasons including for the production of more stems, more tubers, higher yields and to overcome weeds (Table 7). Most mentioned more stems as the principal reason for cultivation.

### *Tipping*

Tipping is the removal of one or two pairs of leaves from the tip part of the main stem and branches. The number of tippings varied significantly between Chencha

Table 7. Percentage of respondents mentioning the indicated principal rationale for cultivation, tipping and earthing up carried out on *P. edulis* in Chencha ( $n = 48$ ) and Wolaita ( $n = 48$ ).

	Chencha	Wolaita	$\chi^2$
<b>Rationale for cultivation</b>			
More stems	42	46	8.9 ( $p = 0.063$ )
More tubers	10	0	
Bigger tubers	4	0	
Higher yield	29	27	
Protect from weeds	15	27	
<b>Rationale for tipping</b>			
More stems	67	81	5.1 ( $p = 0.163$ )
More tubers	4	0	
Bigger tubers	0	0	
Higher yield	25	19	
Short, broad canopy	4	0	
<b>Rationale for earthing up</b>			
More stems	10	19	13.2 ( $p = 0.010$ )
More tubers	13	21	
Bigger tubers	17	13	
Higher yield	60	33	
Others <sup>†</sup>	0	15	

<sup>†</sup>Other reasons include protection of plants from sun burn and burying stolons.

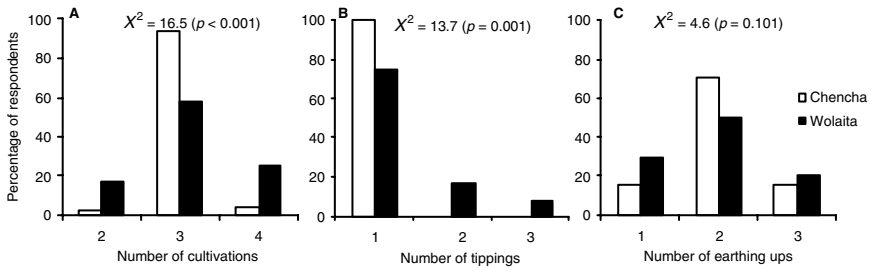


Figure 4. Respondents (%) in Chencha and Wolaita indicating that they cultivated the soil 2–4 times (a), that they carried out 1–3 tipplings (b) and that they earthed up 1–3 times (c). For definition of cultivation see text.

and Wolaita, with only one tipping being carried out in Chencha, and 1–3 in Wolaita (Figure 4b). During group discussions, the farmers mentioned that they carried out the first tipping as soon as the plant reached about 15 cm or had produced 2–3 pairs of leaves, the second tipping one month after the first and the third two months after the second. Most farmers at both sites were convinced that tipping increased the number of stems (Table 7). In addition, some farmers at both sites mentioned it increased yield (Table 7), but – given the labour requirement of this practice – the percentage of respondents who had this opinion was relatively low.

Table 8. Percentage of farmers reporting no occurrence of diseases, insect pests and weeds in *P. edulis* crops, and occurrence with different effects on tuber number and size in Chencha ( $n = 48$ ) and Wolaita ( $n = 48$ ).

	Chencha				Wolaita				$\chi^2$
	No occurrence	Type of effect <sup>†</sup>			No occurrence	Type of effect			
		+	0	-		+	0	-	
Effects on tuber number									
Disease	100	0	0	0	42	13	0	46	39.5 ( $p < 0.001$ )
Insect pest	44	0	0	56	58	4	0	38	6.3 ( $p = 0.430$ )
Weed	0	0	0	100	0	0	10	90	26.9 ( $p < 0.001$ )
Effects on tuber size									
Disease	100	0	0	0	40	10	0	50	41.5 ( $p < 0.001$ )
Insect pest	44	0	0	56	63	4	0	33	9.7 ( $p = 0.290$ )
Weed	0	0	10	90	0	0	0	100	26.9 ( $p < 0.001$ )

<sup>†</sup>+: positive (more or bigger tubers), 0: no effect, -: negative (fewer or smaller tubers).

### Earthing up

Earthing up refers to the piling up of the soil around the stems. Most respondents piled up the soil around the stem twice while some piled up the soil once or three times (Figure 4c). Most respondents carried out the first earthing up in the first 45 days from planting, the second between 90–135 days and the third between 135–180 days from planting. Farmers carried out the earthing up principally to increase yields, whereas some mentioned more stems, more tubers and bigger tubers as their reason for earthing up (Table 7). During the group discussions farmers indicated that they earthed up their crop more than three times in order to cover the stolons that appeared above the soil and to support the branches against the effects of a strong wind.

### Diseases, insect pests and weeds

Diseases were reported to occur only in Wolaita, by about 60 % of the respondents, of which the majority mentioned that diseases reduced the number and/or size of the progeny tubers, and a few claimed that diseases increased the number and/or size of the progeny tubers (Table 8). Insect pests were reported to occur by almost half of the respondents and were considered to have negative effects on the number and size of progeny tubers (Table 8). All respondents reported weed problems. In Chencha, 10 % of the respondents claimed weeds had no effect on tuber size, whereas in Wolaita 10 % of the respondents claimed weeds had no effect on number of progeny tubers (Table 8).

### Harvesting tubers and yield

Harvesting for consumption started earlier in Wolaita than in Chencha (Figure 5). The majority of the respondents in Wolaita started harvesting in October while in Chencha they started in November.

Tubers were harvested by digging with a hoe. Harvesting took place gradually depending upon the need of the family. The number of hills (plants from one planting

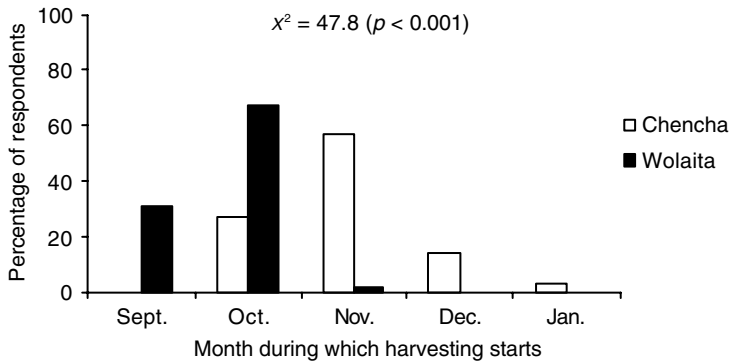


Figure 5. Respondents (%) indicating different months of starting harvesting tubers for consumption in Chencha and Wolaita.

hole) that were dug depended on the family size. During the group discussions it became clear that farmers with large families harvested the tubers from 2–3 hills while farmers with a small family only harvested from one hill. Farmers also indicated that the yield collected from a hill varied depending on various factors including temperature, rainfall and crop management. They indicated that the number of progeny tubers from well-managed farms varied from 80 to 120 per hole and from poorly managed farms varied up to 20 per hole. The fresh tuber yield per hole varied from 500 to 1000 g.

Harvesting tubers for use as seeds started much later than when tubers were to be used for consumption. Harvesting seed tubers was usually done just before planting. When the land was not adequately covered with plant material or debris, seed tubers could start to sprout long before use. In such cases seed tubers were dug up and transferred to a cooler place (see next section).

#### *Storing tubers for consumption and for planting*

Tubers for consumption were stored in situ in the ground, i.e. in the place where the crop was planted, for a maximum period of five months, but usually for a shorter time (Figure 6). During group discussions with the farmers, they indicated that storing for several months was not desirable for it led to changes in flavour, increased the fibre content, and increased the energy needed for cooking. The maximum storage duration was shorter in Chencha than in Wolaita.

Tubers meant for planting, commonly known as ‘seed tubers’, were often left in the place where they were grown until planting. While they were in the ground they were covered with enset and banana leaves, manure or debris to protect them from strong sunlight. In some instances, however, particularly when high temperatures prevailed, farmers moved the seed tubers to other places where there was shade, and placed them in a dug furrow or hole and covered the soil with grasses, enset, banana leaves or any debris. Seed tubers were stored for a shorter period in Chencha than in Wolaita (Figure 6).

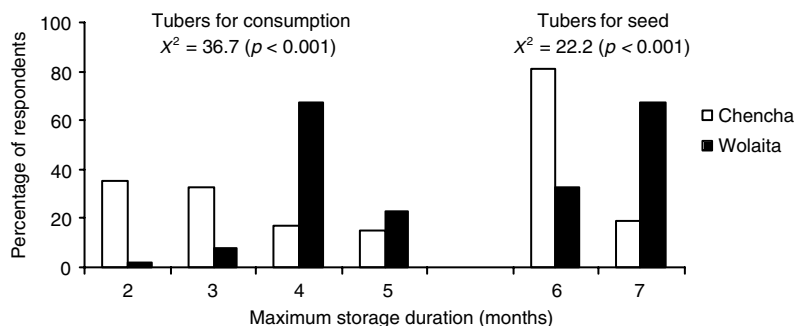


Figure 6. Percentage of respondents indicating the maximum duration of storage of tubers used for consumption or for seed in Chencha and Wolaita.

*Seed tuber acquisition*

Most farmers used at least a quarter of their plants as a source of seed tubers for the next planting season. During the group discussions, farmers indicated that those who did not grow the crop before purchased seed tubers from the local market or directly bought them from the producer farm. They bought different sizes depending on their preferences and stored them in the soil or in their houses. They mostly bought the tuber when the planting time was approaching. Because the availability of seed tubers at the time of planting was less, the price per kg was higher. As learned from the group discussions those farmers who were relatively rich preferred bigger tubers while those who did not have adequate money bought smaller ones. Bigger seed tuber sizes cost an average of US\$ 7–8 per 100 kg while smaller seed tubers cost US\$ 4–5 per 100 kg.

*Reasons for declines in production*

Several production constraints including a shortage of seed tubers, scarcity of land, water availability, poor storage facilities and poor market opportunities were listed as reasons for the decline in production (Table 9). In both Chencha and Wolaita respondents from all wealth categories indicated a shortage of seed tubers as the

Table 9. Percentage of respondents in the three wealth categories mentioning the indicated principal rationale for the decline of *P. edulis* in Chencha (*n* = 48) and Wolaita (*n* = 48).

Rationale	Chencha				Wolaita			
	Poor	Medium	Rich	$\chi^2$	Poor	Medium	Rich	$\chi^2$
Shortage of seed tubers	83	72	100	6.5 ( $p = 0.586$ )	100	91	70	13.4 ( $p = 0.099$ )
Shortage of land	0	6	0		0	3	0	
Water shortage	0	9	0		0	0	10	
Poor storage duration	8	12	0		0	0	20	
Poor market	8	0	0		0	6	0	
<i>n</i> <sup>†</sup>	12	32	4		6	32	10	

<sup>†</sup>Number of respondents in each wealth category.

Table 10. Percentage of farmers mentioning the indicated attitudes towards future production of *P. edulis* in Chench (n = 48) and Wolaita (n = 48).

	Chench	Wolaita	$\chi^2$
Farmers want to continue growing the crop	100	100	0
Farmers' families want to continue consuming tubers	100	100	0
Farmers expect an increase of the area of <i>P. edulis</i> on the farm	100	83 <sup>†</sup>	8.6 ( $p = 0.003$ )

<sup>†</sup>All other farmers expected the area to remain at least constant.

major contributing factor. During the discussions, farmers indicated that a high price of seed tubers, long duration (6–8 months) for the crop to reach maturity and high temperatures which caused greater evaporative loss during crop growth also greatly contributed to the decline in production.

Despite these problems, however, all respondents in both areas wanted to continue growing and consuming the tubers with their families and almost all respondents wanted to increase the proportion of area cropped to *P. edulis* on their farm (Table 10).

## DISCUSSION

### *Farmers interviewed*

The farmers interviewed were taken at random from a long list, obtained through the proper authorities, of farmers growing the crop. Therefore, farmers interviewed in each area were considered as representative of the farmers in those areas growing the crop, in terms of, for example, wealth status, level of knowledge and variation in cultural practices. The group discussions contributed significantly to the understanding of the answers provided by individual farmers. These discussions were always lively and intensive.

### *Indigenous production practices*

Understanding the indigenous production practices is a basic tool for promoting a certain crop. Knowing these practices would enable one to grow the crop, understand yield gaps and make the necessary investigations. Table 11 lists the major practices involved in the production of *P. edulis* in Chench and Wolaita. Most of the practices were similar in the two areas. Explanations of the activities have been given in the remarks column when necessary.

*Differences in cultural practices between Chench and Wolaita.* Farmers in Chench tended to start land preparation earlier than farmers in Wolaita (Table 3). The soils in Chench were often more fertile than those in Wolaita and often were used for the first time by farmers. This had significant consequences for the types of land preparation and for the amount of fertilizer applied. On virgin soil, farmers in Chench did not plough but prepared patches for planting (Table 3). Wolaita farmers on the other hand applied manure more frequently to the crop than most farmers in Chench (Table 6). Chench

Table 11. Standard practices in the production of *P. edulis* in Chencha and Wolaita.

Activity	Description	Remarks
Land preparation		
Digging/ploughing time	January–April	Digging/ploughing takes place following the advent of rain.
Means of digging/ploughing	Tools and animal pulled plough; digging hoe, spade and ox	The digging hoe (toyle) is a common traditional tool and most commonly used. Oxen are used on large plots.
Mode of preparing the land	Furrow, flat, patch and raised bed	Furrow is widely used. The patch method is used by many people in Chencha on virgin and fertile soil.
Spacing	60–100 cm between the furrows, 40–75 cm within a furrow	
Plant population ha <sup>-1</sup>	41 666–133 333	
Furrow depth	15–20 cm	Personal observation
Type of planting material and preparation		
Type of planting material	Tuber pieces, whole tubers, sprout cuttings and stem cuttings	Tuber pieces are used by most growers. The other planting materials are used by few farmers.
Number of tuber pieces prepared from one mother tuber		
Big mother tuber (>15 cm)	Three tuber pieces	
Medium mother tuber (10–15 cm)	Two tuber pieces	
Small mother tuber (5–10 cm)	Two tuber pieces	
Time for preparing tuber pieces	One day before and on the day of planting	Farmers with large areas start breaking the mother tubers in pieces when one day is left for planting.
Sprouting/de-sprouting of tuber pieces	Both are used by many farmers	It is highly possible that there would be breakage of sprouts during transportation and planting.
Number of tuber pieces planted per hole	2–3 pieces	
Planting and subsequent field practices		
Planting time	Mostly in April	Planting in this month is carried out by many as there is adequate rain during this month.
Planting depth	< 5 cm and 5–10 cm	Tubers are placed deeper in the ground as the temperature gets higher.
Fertilization		
Type of fertilizer	Manure	In Wolaita also combined with compost
Number of applications	1→ 3 times	

Table 11. (Continued)

Activity	Description	Remarks
Time of applying fertilization	Application mostly continues until earthing up	
Cultivation		
Number of cultivations	2–4 times	Cultivating three times is most common.
Time of cultivation		
1st cultivation	One month after emergence	
2nd–4th cultivation	Depending on the weed infestation	
Tipping		
Number of tipplings	1–3	Tipping is mostly done once.
Time of tipping	As the young plants reach 10–15 cm in height or have produced 2–3 pairs of leaves. Later tipplings may be carried out depending on the growth, and most commonly with 1–2 month's difference.	
Earthing up		
Number	1–3	Two times earthing up is mostly practised.
Time of earthing up		
1st	Within 45 days from planting	
2nd	90–135 days from planting	
3rd	135–180 days from planting	
Diseases and insect control	None	Disease problems only occur at some fields in Wolaita, insect pests occur in some fields at both sites.
Harvesting and storage		
Months when harvesting tubers for consumption starts	September–January	Most farmers in Wolaita start harvesting tubers for consumption in October and in Chenchu in November. Tubers mature later in Chenchu than Wolaita because of lower temperatures.
Storage method for tubers for consumption	In situ (field)	
Maximum storage duration for consumption	2–5 months	Many keep tubers in the ground for 2–3 months.
Storage method for seed tubers	In situ (field)	As the temperature gets higher tubers are taken to a shady area and buried in the ground.
Maximum storage duration for seed tubers	6–7 months	A greater proportion of the tubers would decay and be lost when stored longer.



farmers tended to cut the seed tubers earlier before planting and consequently more Chenchu farmers paid attention to drying of the seed tubers than in Wolaita (Table 5). Farmers in Chenchu tended to tip only once (Figure 4b) with the same frequency of earthing up (Figure 4c) as farmers in Wolaita. Note that the agronomic purposes of tipping and earthing up are very similar and that both activities require a lot of labour. When this labour requirement occurs in the same part of the growing season and coincides with labour demands for other crops, the decision to carry out a tipping will have to be made in line with the decision on earthing up. Tipping may be less effective without earthing up as the extra stems and stolons produced will hardly produce extra tubers in that case.

*Use of tuber pieces.* The respondents in both areas broke whole tubers into pieces before planting to encourage the production of more stems, more tubers and higher yields. In other crops propagated from tubers, for instance Irish potato, tuber pieces are primarily used to increase the number of propagules (Beukema and Van der Zaag, 1979) and also to break dormancy, enhance sprout growth and increase stem numbers (Beukema and Van der Zaag, 1979; Struik and Wiersema, 1999). In *P. edulis*, however, since the mother tubers are cut into 2–3 pieces (depending on the size of the tuber; Figure 2) and 2–3 tuber pieces again are planted per hole (Figure 3b), breaking is likely to enhance the production per hole. Breaking may also stimulate a uniform emergence of stems per hole, and increase the number of stems, branches and leaves, and as a result increase the crop cover and total production per hole. In addition the high number of stems may give rise to more progeny tubers. Because none of the respondents indicated that using tuber pieces increased the size of progeny tubers, the effects on tuber number are likely to be more prominent.

*Planting seed pieces.* On average over the two areas, almost half of the respondents planted the tubers with sprouts and the others after de-sprouting. Most users of sprouted tuber pieces favoured the presence of sprouts because it advances and enhances growth and increases yield; most users of de-sprouted tubers favoured de-sprouting because it stimulates more stems to be formed. The effect of planting tubers with their sprouts or after de-sprouting is known from other crops. For instance, in the Irish potato planting de-sprouted tubers increases the number of stems and final tuber yield (Beukema and Van der Zaag, 1979; Struik and Wiersema, 1999). However, these effects depend strongly on physiological age of the seed tuber, the period of pre-sprouting and several other factors.

The greater proportion of the respondents in both areas planted the tuber in a furrow at a soil depth of < 5 cm (Figure 3a). When high temperatures prevailed, farmers covered the tuber with a thicker layer of soil (5–10 cm). It is unknown, however, how temperature affects the growth and tuber production of *P. edulis*.

*Manuring.* Manuring is widely practised in both areas: respondents used it to obtain more and larger progeny tubers (Table 6). In the Irish potato, both manure and chemical fertilizers have been used to enhance growth and tuber production (Beukema and Van der Zaag, 1979; Borgel *et al.*, 1980). However, farmers did not use chemical fertilizer on *P. edulis* (Table 6) in either area.

*Tipping.* Tipping is a crop-specific practice employed by all farmers in both areas, although the practice is considered to be time-consuming by most farmers (see also above). It is thus likely to have a significant effect on crop performance. The vast majority of the respondents in Chencha indicated that tipping enhanced stem numbers (Table 7). However, the mechanism through which tipping affects the crop's performance is still unknown. Removing the stem apex will break apical dominance and is likely to result in extra above-ground branches. This increased branching may enhance light interception by the canopy and thus increase dry matter production. It is still unknown how tipping affects the below-ground parts of the crop. For example, it is not known whether tipping causes more main stems, more stolons and more tubers to be formed. The proportion of respondents indicating that tipping increased tuber yield was also low. This is surprising given the amount of labour required for this practice.

*Earthing up.* Piling up of soil around the stem was a common practice and the majority of respondents carried it out twice (Figure 4c). Respondents in both areas earthed up around the stem to increase yield (Table 7). They also mentioned that this practice would increase the number of stems, the number of tubers or the tuber size (Table 7). This practice is also carried out with the Irish potato in order to bury the stolons, increase the production by increasing the number of tubers and to avoid tuber greening (chlorophyll formation) (Beukema and Van der Zaag, 1979). It is not known how the piling up of soil affects the above- and below-ground growth of *P. edulis*. As it is hard work, knowing the optimum number and the time of piling is essential.

There was not really a good positive correlation between the number of tippings and the frequency of earthing up. On the contrary, these activities might compete for the amount of labour available. However, both serve similar goals.

#### *Major production constraints*

In identifying the possible causes for the decline in the production of *P. edulis* (see Introduction), respondents in both study areas indicated as possible reasons: shortage of seed tubers, long storage duration, water shortages and poor markets (Table 9). All wealth groups in both areas indicated shortage of seed tubers as a major constraint. This constraint may be alleviated by designing multiplication systems and methods with higher rates of multiplication than the 1:4 current for *P. edulis*. Other important constraints indicated were long storage duration in Wolaita (to be solved by improving storage facilities and techniques) and shortage of land in Wolaita (Table 9). Farmers also mentioned the long growing period and introduction of new crops such as Irish potato and sweet potato as constraints.

To alleviate similar problems in Irish potato several studies were carried out. For instance, to overcome shortage of seed tubers experiments were carried out using in vitro-produced propagation material (Lommen, 1999; Struik and Lommen, 1999), studying the effects of storage conditions on tuber production (Beukema and Van der Zaag, 1979; Moorby, 1978; Ronsen, 1978) and the problems related to diseases, insects

and weeds (Struik and Wiersema, 1999). In almost all cases techniques, methods and cultural practices have been designed through which the problems could be overcome in economic ways. However, *P. edulis* is an orphan crop in national and international research; research to overcome the production constraints in this crop does not exist. We have initiated a research project to (at least partly) fill this gap by studying the crop physiology and ecology of *P. edulis* and by analysing the agronomic and crop physiological effects of tipping, different sizes of tuber pieces and the physiological age of mother tubers.

#### CONCLUSIONS AND RECOMMENDATIONS

- *P. edulis* has been grown and used as a major source of food in many parts of Ethiopia and is liked as a tasty source of carbohydrates.
- In Chench and Wolaita, cultural practices for this crop are laborious and time consuming. In most cases the techniques used in the two areas are the same.
- Information on the farmers' production practices in this crop was basically lacking and that in itself is an important constraint in developing the crop.
- We have described the general cultural practices of the crop to provide the scientific community with information needed to evaluate further and investigate the crop. Our research may also assist agronomists, extensionists and breeders to improve the crop.
- The major production constraints are shortages of seed tubers, poor storability, and water shortage.
- Farmers do report attacks by diseases and insect pests in *P. edulis*.
- Traditional cultural practices include time-consuming and laborious techniques such as tipping and earthing up, which are both supposed to increase stem number and thus yield. These techniques may also increase tuber number. The physiology behind this and especially the reasons why *P. edulis* produces so few tubers without these stimulating techniques need to be studied in detail.

*Acknowledgments.* The authors would like to acknowledge the *P. edulis* farmers of Chench and Wolaita for providing the necessary information and sharing their experience, the Ethiopian Science and Technology Commission and Norwegian Agency for Development and Corporation (NORAD) for their financial support.

#### REFERENCES

- Admasu Tsegaye and Struik, P. C. (2002). Analysis of enset (*Ensete ventricosum*) indigenous production methods and farm based biodiversity in major enset-growing regions of southern Ethiopia. *Experimental Agriculture* 38:291–313.
- Asfaw, Z. and Zerihun, W. (1997). Crop associations of home-gardens in Welayta and Gurage in southern Ethiopia. *SINET, an Ethiopian Journal of Science* 20:73–90.
- Aresawem, M. (1993). Study report in Ezo Tula kebele peasant association, Northern Omo zone, Chench wereda. *FARM Africa, Addis Abeba, Ethiopia*.
- Beukema, H. P. and Van Der Zaag, D. E. (1979). *Potato Improvement: Some Factors and Facts*. Wageningen: I.A.C.
- Borgel, H., Arend, B., Jackobi, C., Kanyarukiga, S., Kullaya, A., Lemaga, B., Mogaeka, S. and Prante, W. (1980). Production, marketing and consumption of potatoes in the Ethiopian highlands (Holleta, Awassa, Alemaya). *Studien, Seminar für Landwirtschaftliche Entwicklung, Fachbereich Internationale Agrarentwicklung, Technische Universität Berlin IV/29*.

- Codd, L. E. (1985). *Flora of Southern Africa, Volume 28, Part 4: Lamiaceae*. Pretoria: Botanical Research Institute, Republic of South Africa.
- CSA (Central Statistical Authority) (2000). *Ethiopian Statistical Abstract*. Addis Ababa: CSA.
- DeWalt, B. R. (1994). Using indigenous knowledge to improve agriculture and natural resource management. *Human Organization* 53:123–131.
- FARM Africa (1999). Report of diagnostic survey using participatory Rural Appraisal (PRA) Techniques on Dorze Laka peasant association in Chencha Wereda of North Omo zone. *FARM Africa, Addis Ababa, Ethiopia*.
- Greenway, P. J. (1944). Origins of some of East African food plants (Part 1). *East African Agricultural Journal* 10:34–39.
- Kay, D. E. (1973). *Root Crops*. London: Tropical Products Institute.
- Lommen, W. J. M. (1999). Causes for lower tuber yields of transplants from *in vitro* potato plantlets of early cultivars after field planting. *Journal of Agricultural Science Cambridge* 133:275–284.
- Moorby, J. (1978). The physiology of growth and tuber yield. In *The Potato Crop: the Scientific Basis for Improvement*, 153–194 (Ed. P. M. Harris). London: Chapman and Hall.
- Ronsen, K. (1978). Seed potatoes stored at different temperature. *Field Crop Abstracts* 31:515.
- Ryding, O. (2000). A new species of *Plectranthus* (Lamiaceae) from Ethiopia and Kenya. *Nordic Journal of Botany* 20: 43–46.
- Siegenthaler, I. E. (1963). Useful plants of Ethiopia. *Experiment Station Bulletin, No. 14. Vol. 1*. Alemaya: Imperial Ethiopian College of Agricultural and Mechanical Arts.
- Struik, P. C. and Wiersema, S. G.. (1999). *Seed Potato Technology*. Wageningen: Wageningen Pers.
- Struik, P. C. and Lommen, W. J. M. (1999). Improving the field performance of micro- and minitubers. *Potato Research* 42:559–568.
- Tindall, H. D. (1983). *Vegetables in the Tropics*. London: Macmillan Press.
- Westphal, E. (1975). Agricultural systems in Ethiopia. Agricultural Research Report. Wageningen: Centre for Agricultural Publishing and Documentation.